

# ReSound custom hearing aids bring modern style and rechargeability to users

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## ABSTRACT

Although custom hearing aids make up a much smaller proportion of hearing aids sold than in decades past, many users prefer them, and they are generally easier to use than other styles. Furthermore, custom hearing aids provide Hearing Care Professionals with an effective way to differentiate their practices. ReSound introduces Customs by ReSound rechargeable custom hearing aids designed to blur the distinction between consumer wireless earbuds and hearing aids. Not only can this be an attractive solution for people concerned about the stigma of wearing hearing aids, but the rechargeable design has also been carefully developed to maximize usability. This paper presents findings of studies related to battery handling, usability of the rechargeable solution, and reliability of the wireless connectivity in ReSound custom hearing aids.

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Custom hearing aids provide Hearing Care Professionals (HCPs) with an effective way to add value to their services and differentiate their practice.<sup>1</sup> Yet the share of custom hearing aids dispensed has dramatically declined over the past 15 years, with sales trends strongly favoring Receiver-in-the-Ear (RIE) hearing aid styles. Today, 79% of hearing aids dispensed in the US market are RIEs.<sup>2</sup> While there are good reasons for the popularity of this style, it is certainly also the case that some people who are fit with RIE might prefer and be more satisfied with custom hearing aids. The value of the individualized product and service can contribute to this satisfaction. In addition, there are distinct advantages associated with custom hearing aids that are easily recognized by users. For example, they can be comfortably worn with eyeglasses and facemasks, and they have been found to be easier to use than BTE styles. This latter benefit can be especially important for the oldest users, many of whom have continued to prefer custom hearing aids over decades of wearing them. In a large study focused on ease of use, 244 older adults were fit with either BTE, ITE or ITC hearing aids. It was found that the custom styles – and especially ITE – were indeed the easiest for people to manage.<sup>3</sup> Hearing aid manipulation skills such as insertion and removal, operation of controls and changing battery were evaluated at the fitting and across follow up visits. It was found that the in-the-ear hearing aids were the easiest to use. The advantages in terms of ease of use for the custom hearing aids have been echoed in other studies.<sup>4,5</sup>

Another significant feature of today's custom hearing aids is that they can double as earbuds; users can connect to phone calls and streaming while also enhancing these sources of in-

put. The mainstream use of earbuds has normalized wearing devices in the ear. Many people use earbuds throughout the day, even when talking to people in the same room. This is possible because many earbuds have a “hear through mode”. This has changed the social cue signaled by wearing earbuds from “I am closed off and focused on my own listening” to “I am connected to my own media, but also to the surroundings when I choose to be”. In a study of social acceptability of wearable devices, earbuds scored higher than other types of devices – such as smart glasses.<sup>6</sup> High ratings of social acceptability indicate that people feel comfortable using the earbuds in social situations and that others feel comfortable communicating with those wearing earbuds. Wearing hearing aids that resemble earbuds could convey a youthful vibe which may appeal to people who are hesitant about wearing them due to the age stigma associated with needing them.

For HCPs, the individualized aspects of custom hearing aids combined with ease-of-use and modern connectivity features is great news. With ReSound custom half shell/ITC and full shell hearing aids, we introduce rechargeability and design that borrows from consumer wireless earbuds to blur and challenge traditional ideas of how hearing aids should look and perform (Figure 1). These hearing aids can fit the needs of a diverse group of people with hearing loss who want a comfortable, cool, and easy-to-use device. Like all ReSound hearing aids, the ReSound custom models are based on the Organic Hearing philosophy. The principles behind Organic Hearing are to bring users ways to hear naturally, feel natural and connect naturally to their surroundings. Like ReSound ONE, the custom hearing aids use technologies inspired by

the natural ear and the ways we use our hearing to help users listen and engage with others with less effort. By adding rechargeability to custom hearing aids, the physical effort and challenges of using them can be reduced. Besides not needing to change batteries, a unique feature of the custom rechargeable system is that the charger has custom charging pockets that put the hearing aids in the perfect position for easy placement in the ears. The right hearing aid is always on the right side of the charger and the left hearing aid is on the left. The charging pockets are individually positioned in the charger to allow the user to place them in their ears without having to change the way they are holding the hearing aid in their hand. To make things even easier, the hearing aids turn on when removed from the charger so they are ready to go.



Figure 1. Customs by ReSound rechargeable custom hearing aids resemble consumer wireless earbuds. The charger includes custom fabricated charging pockets that are oriented to make it easy for users to remove the hearing aids and put them in their ears.

In this paper, we review how our study of users' interactions with conventional disposable hearing aid batteries informed the development of ReSound rechargeable solutions, as well as how the ReSound rechargeable custom hearing aids can further contribute to ease of use. Finally, we compare the range of wireless connections between Customs by ReSound and the ReSound ONE hearing aids styles to demonstrate reliable connectivity across the ReSound product line.

### **Study 1: Users' handling of disposable hearing aid batteries**

It has been reported that 88% of hearing aid users are satisfied with changing batteries in their hearing aids.<sup>7</sup> While this percentage is likely inflated, it is still high and consistent with a study carried out at ReSound that showed a disconnect between perceived and actual experience of handling hearing aid battery changing.<sup>8</sup> The purpose of the study was

to explore the ways in which hearing aid users manipulate disposable hearing aid batteries. By analyzing their interactions with batteries, it was possible to assess different user interaction designs to improve usability in future hearing aid generations, leading to the current ReSound rechargeable solutions.

Twenty-two adult hearing aid users ranging from 57 to 92 years old (mean 72 years) participated in the study. They were asked to rate how often (from "never" to "always") they encountered difficulty with battery related tasks including remembering to buy batteries, being able to find their batteries, opening the battery compartment, loading and unloading the batteries, gripping the batteries and hearing aid, and needing help with any of the tasks. All the mean ratings were either "never" or "rarely" and only three individuals rated having difficulty with any tasks as "once in a while". The "often" and "always" rating categories were not used. These results indicate that the participants did not perceive any difficulties in managing their hearing aid batteries.

The second part of the study measured the time required to load and unload two common battery sizes in RIE hearing aids. A test board made of corrugated cardboard with 10 depressions contained 10 RIE hearing aids and 10 batteries that were either size 312 or 10A.

The actions required in this experiment are similar to those required in tests of dexterity, including the Purdue Pegboard Test<sup>9</sup> and the Jepsen-Taylor test of Hand Function.<sup>10</sup>

For load trials, the task was to pick up a hearing instrument, load the battery into the instrument, close the battery door, put the instrument back on the board, and press a button indicating that they've finished the trial. They practiced loading two batteries into two instruments. When they were certain that they understood the task, they unloaded the two practice batteries, and then loaded the ten batteries into the ten instruments.

For unload trials, the task was to pick up a hearing instrument, remove the battery, place the battery and hearing instrument back onto the board, close the instrument door, and then press a button indicating that they've finished the trial. Again, they practiced unloading two instruments before reloading them and unloading all ten. All trials were recorded on video.

The main quantitative measurement was the number of seconds required to load or unload a single hearing instrument. Timing for each trial started when the subject picked up the hearing instrument and ended when the subject released the hearing instrument. Trial completion times were rounded to the nearest second.

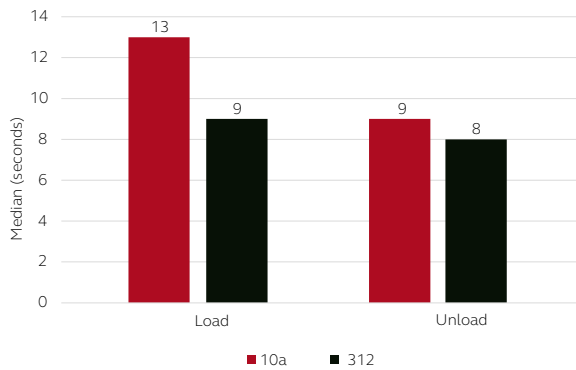


Figure 2. Median time required by test participants to load and unload disposable batteries from RIE hearing aids. The smaller battery required more time to handle. Characteristic strategies were observed for how people performed the tasks.

As is clear from Figure 2, it takes longer to load a 10a battery (median 13 sec/mean 16.8 sec) than it takes to load a 312 battery (median 9 sec/mean 10 sec). A one-sided t-test verified that this difference is significant ( $p < 0.01$ ). However, it does not take significantly longer to unload a 10a battery than it takes to unload a 312 battery (one sided t-test,  $p = 0.16$ ).

It is worth noting that there was substantial individual variation in trial completion times. For example, there were two participants who consistently loaded the 10a battery in 3-4 seconds, and two participants who occasionally required more than 60 seconds to load the 10a device. The distribution of times highlights some interesting features of this data. First, trial completion times in all 4 trial types are skewed right. In other words, there are many more trials with times greater than average than there are trials with times less than average. This happens because it is much easier to end up with a long trial than it is to end up with a short trial. One might have a long trial because one is distracted, drops the battery, or accidentally loads the battery upside down. By contrast, there is only one way to have an unusually short trial: produce every movement correctly and efficiently. And no matter how well the trial goes, it is not possible to end up with a time less than 0 seconds; this also favors a right-skewed distribution of load and unload times. A second observation is that the spread in 312 load and unload times is smaller than the spread in 10a load and unload times, meaning that there is a wider range of common trial completion times in the smaller 10a batteries. But the fastest times are similar for the two sets of batteries. Together, these observations imply that a participant with relatively poor battery manipulation skills (e.g., due to poor vision or dexterity) will slow down more with a 10a battery than they will with a 312 battery.

Qualitative observations of the videotapes were made concurrently with quantitative measurements. It was possible to identify common loading and unloading strategies, such as flipping the device over repeatedly to achieve a particular orientation before attempting to open the battery door, and shaking the device vigorously to remove the battery. These

observations were key in steering development of a rechargeable solution toward encased batteries with a separate, easily manipulated charger rather than solutions based on removable rechargeable batteries. Removable batteries would solve some issues associated with disposable ones, but still presented challenges in terms of ease-of-use.

## Study 2: Comparison of handling of rechargeable RIE and custom hearing aids

As discussed previously, custom hearing aids have been reported to be easier for users with reduced dexterity to manage. However, data supporting this idea is quite old and most of the studies compare to BTE hearing aids with earmolds to custom hearing aids. Today, RIE hearing aids are the most sold hearing aid style, and many people are fit with non-custom domes attached to the receiver modules rather than custom earmolds. Domes could make insertion of RIE hearing aids easier for users as they don't need to be oriented in a particular way as a custom earmold does. At the same time, the receiver wires are less sturdy than the standard tubing used to fit BTE hearing aids, and could be more challenging to feel, grasp and use to correctly steer both the dome and device into place. To update our knowledge on how some aspects of usability may differ for rechargeable RIE and custom styles, a study was conducted to find out how quickly and easily experienced hearing aid users could take a pair of hearing aids from a charger and insert them correctly in their ears. ReSound ONE rechargeable RIE and ReSound rechargeable custom hearing aids were used. Data was collected from eight participants. Five of the participants had previous experience with custom hearing aids.

For each condition, the test leader demonstrated how to remove the hearing aids from the charger and insert into the ears. The participants then practiced inserting the devices before trial rounds. Half of the participants began with the RIE condition and half began with the custom hearing aid condition. Three rounds were performed for each test condition. The test was timed using a video recording.

Figure 3 shows the average of the 3 trials for each condition as well as the overall average time for all participants. All individuals were faster in the custom rechargeable condition than the RIE condition. Like the results of study 1 where participants loaded and unloaded disposable batteries, there was quite some individual variability in how much faster. Participants A, F and E showed only a few seconds' advantage with the custom rechargeable condition, while participants B, C and E were approximately 10 seconds faster with the rechargeable custom hearing aids. Two individuals – participants D and G - were much slower than all others. Overall, participants were able to open the charger, remove the hearing aids, and place them correctly in their ears twice as fast with the rechargeable custom style than with the RIE style. With the rechargeable custom style, the average time to complete the task was 12 seconds whereas it took an average of 25 seconds to complete the task with the rechargeable RIE. A paired t-test indicated that the speed advantage with the custom style was significant ( $p < .05$ ).

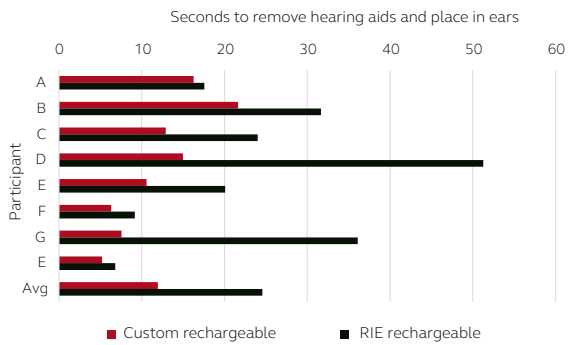


Figure 3. Time required by test participants to remove hearing aids from the charger and place them correctly in their ears. The letters A through E are individual results. On average, participants could complete the task twice as fast with the rechargeable custom hearing aids compared to the rechargeable RIE hearing aids.

### Study 3: Connectivity range of different hearing aid styles

In addition to enhancement of some sound processing features, wireless connectivity in hearing aids gives users a convenient way to adjust their hearing aids as well as receive phone calls, music and other audio directly from smartphones and other devices. Regardless of the style of hearing aid, users should expect robust wireless connectivity such that they can turn their head or body or have their device in a pocket or bag and still maintain connection. Achieving consistent performance is complex regardless of the hearing aid style. However, it is most challenging for custom hearing aids. This is in part because the device rests inside the ear. Each ear is unique, affecting how the components – including the antenna for wireless connectivity – are placed in building each hearing aid. In addition, the 2.4 GHz frequency band in which the wireless functions operate does not transmit through human tissue. Thus, the antenna must be both thoughtfully engineered and carefully manufactured to realize reliable connectivity that is comparable to BTE and RIE hearing styles where the antenna is outside of the ear and located in precisely the same position in every device that is produced.

To illustrate how wireless connectivity performance compares across ReSound hearing aid styles, ReSound custom half shell/ITC hearing aids were manufactured for 1 female and 2 male adult volunteers with normal hearing. In addition to the custom devices, each person was also fit with ReSound ONE 963 RIE with MP receivers and appropriately sized open domes, as well as ReSound ONE 977 BTE with thin tube and open domes. Low gain settings were used to allow them to hear and assess the quality of wireless connection. For each trial, the hearing aids were paired to an iPhone 8, and instrumental music was played from the phone.

The test was done outdoors in an empty parking lot to eliminate reflections that could confound the results. The investigator faced the participant at approximately 1 meter's distance while holding the phone. Audio streaming to the hearing aids was started and the participant was able to listen for a brief period to establish a quality reference. The participant then moved slowly away from the investigator,

turning 90 degrees every few steps. The participant stopped at the distance where the audio began to break up, indicating a poorer quality connection between the phone and the hearing aids. This distance was noted, and the procedure was repeated such that all three hearing aid styles were tested. The average of the distances for each style are shown in Figure 4. There were no significant differences among the styles, although there were differences in range among participants. The shortest connectivity range was 6 to 7 meters and was experienced by one participant. The other two participants experienced similar connectivity ranges at around 8.5 meters. These results indicate that connectivity performance within an individual can be expected to be the same for different ReSound wireless hearing aid models, but that performance between individuals may vary.

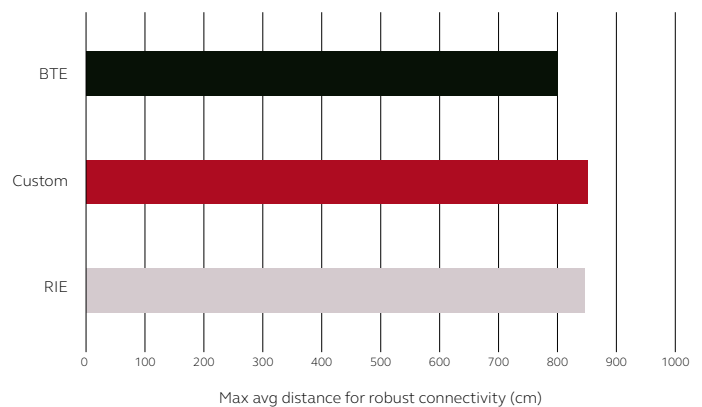


Figure 4. Average distance where the wireless connection broke down for each ReSound wireless hearing aid style. No significant differences in range were found.

### Summary

Custom hearing aids are less frequently dispensed than the RIE style today. However, many users prefer and may even be better served with custom hearing aids. The ReSound custom hearing aids are designed to leverage the popularity of consumer wireless earbuds, offering users similar appearance and functionality. Custom hearing aids have been shown to be easier to use than BTE styles, and the design of the ReSound rechargeable custom hearing aid solution addresses the remaining issue in handling custom hearing aids – battery management. User interaction with disposable hearing aid batteries was studied, leading ReSound to develop a system where the power supply is encased in the devices and the hearing aids are placed in a charger. Although the rechargeable solutions for ReSound ONE styles are easy to set up and use, the Customs by ReSound solution was shown to be even easier. Finally, the range of connectivity for ReSound custom wireless hearing aids compare to ReSound ONE hearing aid styles was shown to be equivalent, which means that users who prefer custom hearing aids need not compromise on the reliability of the wireless connections due to the device components being inside their ears.

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